## 4C Lab: Thermal Conductivity

**Goal:** To determine the composition of a thermal insulator by finding its thermal conductivity, *k*.

**Equipment List:**

- Pasco steam generator with stopper and tubing
- Pasco steam chamber
- Ice block with Styrofoam cover
- Sample (wood, lexan, Masonite or sheetrock)
- Vernier calipers
- Timer
- Triple beam balance
- Collecting cups
- Paper towels

**Background:** The thermal conductivity, k, is a constant which measures how well or poorly a material conducts heat. The thermal conductivity is related to the heat transferred by:

$$k = \frac{H\,\Delta x}{A\Delta T} \quad where\ H, the\ heat\ current\ is:\ H = \frac{\Delta Q}{\Delta t}$$

To find the thermal conductivity, the material tested is clamped between a steam chamber, which maintains a constant temperature of 100oC, and a block of ice which maintains a constant temperature 0oC. A fixed temperature differential of 100oC is established. The heat transferred is measured by collecting the water from the melting ice. The ice melts at a rate of 1 gram per 80 calories of heat flow or 333.5 J/g. This is the latent heat of fusion. From this we find *ΔQ:*

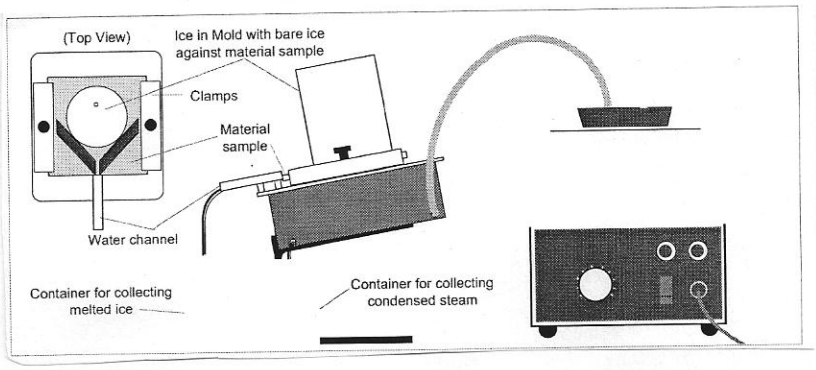
$$\Delta Q = \Delta m\, L_f$$

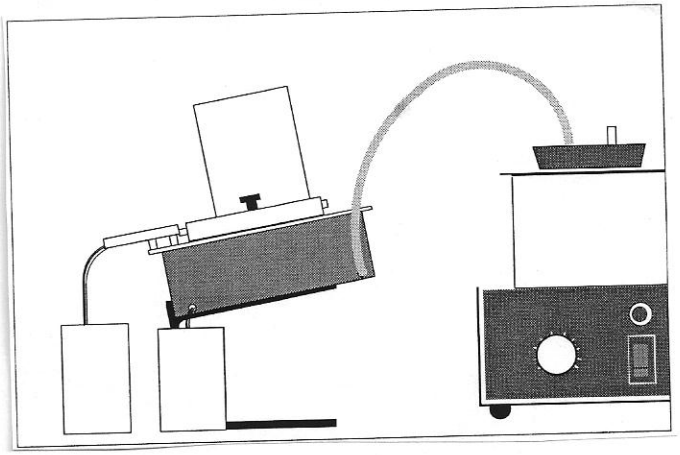
Thus the thermal conductivity can be expressed:

$$k = \frac{\Delta m L_f \Delta x}{\Delta t A \Delta T}$$

*A* = area of ice in contact with sample
*Δx* = thickness of sample
*Δm* = mass of melted ice
*ΔT* = temperature differential
*Δt* = time during which the ice melted

**Diagram of setup:**



**Procedure:**

1. Set up the apparatus as shown.
   Fill the steam generator about 2/3 full and set it to 7 but do not attach the tubing yet.
2. Measure:
   $m_{cup}$, the mass of the collecting cup and
   $\Delta x$, the thickness of the sample
3. Mount the sample onto the steam chamber and place the ice on top. (Please be careful removing the ice from the mold.)
4. Find the ambient melting rate for the ice by collecting melted ice for 10 minutes. Assume that the ambient melting rate is constant.
5. Run steam into the chamber. Let the steam run for several minutes until the temperatures stabilize. Place a container under the drain spout for the condensed steam.
6. Measure the diameter, $d_1$, of the ice and empty the collecting cup. Collect melted ice for 10 minutes, measure the collected water and the diameter of the ice, $d_2$.
7. Empty the collecting cup again, collect melted ice for 10 minutes. Measure the final diameter of the ice, $d_3$ and the mass of collected water.

**Analysis:**

1. Find the average diameter for your two trials. $d_{av1} = ½ (d_1 + d_2)$ for trial 1 and $d_{av2} = ½ (d_2 + d_3)$ for the second trial.
2. Calculate k for each trial and average.
3. Compare with the accepted values. Expect 10 – 15% error under normal conditions.

$k_{wood}$ = 0.11 – 0.14 W/mK
$k_{lexan}$ = 0.19 W/mK
$k_{sheetrock}$ = 0.43 W/mK
$k_{masonite}$ = 0.047 W/mK